

HEMODYNAMICS OF ARTERIAL AND VENOUS CIRCULATION IN THE INTRAUTERINE FETAL EVALUATION

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Original paper ABSTRACT

Introduction: The purpose of each antenatal control focuses on the detection and prevention of hypoxic-ischemic injury and fetal death (1)) using modern biophysical tests and Doppler parameters. **Goal:** This study examines the correlation of changes in arterial compared to venous hemodynamics of the fetus and is determined by the most sensitive and most specific Doppler parameter in the assessment of intrauterine fetal status. **Material and Methods:** The study was conducted as prospective and included 119 pregnant women. All subjects

underwent NST (nonstress test), and Doppler measurements of blood flow in the umbilical artery (Aum), fetal aorta (Ao) and the central cerebral artery (MCA). In case of borderline and pathological arterial flow was measured through the ductus venosus (DV) and umbilical vein (VU). At birth to the child was determined umbilical artery blood pH and Apgar score (AS) in the first minute. Based on the clinical condition of the newborn and outcome was calculated perinatal morbidity and mortality. **Results:** In all cases with a pathological arterial flow, which is verified during measurement also the pathological venous flow and confirmed

fetal acidemia at birth and low Apgar scores? In this group, the two neonates died in the first week. **Conclusion:** There is a justification for the analysis of venous flow in the event borderline and pathologic findings in fetal arterial system. It has been proven that the cerebroumbilical (C/U) index is most effective parameter in predicting changes in the venous system and this the most sensitive Doppler parameter in predicting fetal acidosis and the most specific Doppler flow through the central cerebral artery. **Key words:** intrauterine status of the fetus, fetal arterial and venous flow rates, fetal acidemia, perinatal mortality and morbidity

1. INTRODUCTION

The most common cause of perinatal morbidity and mortality is hypoxia (50 to 60%) so it is in perinatal control of the most importance fetal oxygenation assessment, in order that in the case of problems with oxygenation could be made timely decisions concerning the pregnancy termination, before the emergence of permanent birth defects. The purpose of each antenatal control focuses on the detection and prevention hypoxic-ischemic damage and fetal death (1), using modern biophysical tests and Doppler parameters.

Measurement of arterial flow today is the standard noninvasive method to estimate the degree of vulnerability of the fetus (2,3,4). Monitoring arterial Doppler parameters can perceive circulatory centralization which the fetus adapts to the development of hypoxia or

we can verify the absence of end diastolic flow and reverse flow in the umbilical artery or fetal aorta, which already represent a sign of fetal asphyxia.

Since the venous flow is the indication of right heart failure, changes in fetal venous flow will demonstrate end of compensatory possibilities of arterial flow and the start of hypoxia in the brain and heart, which will be reflected in changes in cardiotocographic finding. Verification of pathological Doppler parameters of arterial flow calls for analysis of fetal venous flow. Result of redistribution of arterial blood causes the consequent load for the right ventricle causing pulsations in VCI and DV as well as VU (2, 3, 5, 6).

Contraction power of the right ventricle is reduced, while the changes that occur in the venous flow precede changes in the cardiotocographic record, as a conse-

quence of right heart dysfunction and myocardial hypoxia. Therefore, changes in the arterial flow showing circulatory centralization are still fetal physiological response to decreased oxygenation, which can last for some time, because the required amount of oxygen arrives in vital organs (3, 4, 7, 8, 9, 10).

At a time when the fetus can no longer deepen adaptation in response to hypoxia developed is right heart failure, changes in the CTG-indicating acidosis and possible damage to the fetus. This means that changes in the arterial circulation require monitoring of flow in the venous circulation and when changes occur in the venous circulation of such a pregnancy should be terminated right away because it will quickly reach heart failure and irreversible changes in the CNS (11-15). In future pregnancies we will not wait for these changes but we

will terminate the pregnancy earlier, according to changes in arterial flows and CTG findings.

In premature children we have to longitudinally and gradually track changes of venous circulation and thus timely make decision on the pregnancy termination, before the onset of fetal asphyxia. Testing venous circulation, are additional tests in monitoring premature children who were exposed to hypoxia. Changes in venous circulation allows recognition of the critical point, after which develops myocardial hypoxia and brain infarction and permanent damage to the fetus (2, 3, 13, 16, 17, 18). Most previous studies have shown that the introduction of Doppler flow measurements through the Aum in the protocols for monitoring high-risk pregnancies significantly reduce perinatal mortality (15).

2. GOALS

a) to examine the correlation between changes in arterial values in relation to venous hemodynamics in predicting fetal respiratory reserves;

b) determine the most sensitive and specific Doppler parameter in the assessment of intrauterine fetal condition.

3. MATERIALS AND METHODS

Testing was conducted in a prospective study, which included 119 pregnant women who were admitted to the perinatology ward of the Gynecology-Obstetrics Clinic in Banja Luka. Examined are pregnant women with different clinical diagnoses, different age, parity, reliable gestational age of 27 weeks or more at birth and with single fetus pregnancies without congenital abnormalities.

Upon admission from a pregnant woman was taken the medical history, performed a clinical examination and made obstetric cardiotocographic record–non-stress test (NST) for 30 minutes and the speed is 1 cm per minute, with the appliance Hewlet Packard 8040 A.

All measurements of color Doppler flow through the umbilical artery (Aum), fetal aorta (Ao) and the central cerebral artery (MCA) are

performed at the stage of fetal rest, in fetal apnea, which is defined by the absence of visible changes in the form of more than 10 continuous Doppler waves. Measurements are performed by ultrasound „real time“ unit General Electric GE LOGIQ Book XP convex with probe of 3.5 MHz.

We measured the resistance index (RI) and pulsatile index (PI). For all calculations we used ultrasound machines mentioned above software. The measured values are compared with the standard values adjusted for gestational age in physiological pregnancies. Sonograms of fetal venous flow were classified as regular and pathological. Pathological flow through the ductus venosus (DV) is one where at one point there is absent or reversed wave „A“, i.e. no or reversed blood flow during systole of the atrium and abnormal flow through the DV is the one where there is an increased flow of wave „A“. Pathological venous flow in the VU is the one where we present the flow pulsation in the vein.

Measuring flow through the umbilical vein (VU) is performed in free curve of the umbilical cord in cross section.

A definitive assessment of the child's status at birth were made by determining the pH of blood from the umbilical artery (Aum) and viability assessment of the newborn Apgar score (AS) 1 and 5 minutes after birth.

We analyzed the findings that are not older than seven days before the birth of the fetus and if done repeatedly, we analyzed the last ones.

After delivery, we followed the clinical condition and outcome of newborns and on that basis calculate perinatal mortality and morbidity.

Research data were statistically analyzed.

4. RESULTS

We analyzed the changes in fetal venous flow compared to borderline and pathological Doppler flow in the umbilical artery (Aum), fetal aorta (Ao) and cerebral medial artery (MCA).

RI Aum	DV-VU		Total
	Regular	Pathological	
Borderline	10 [100.0%]	0 [0.0%]	10 [38.5%]*
AEDF	7 [77.8%]	2 [22.2%]	9 [34.6%]**
REDF	0 [0.0%]	7 [100.0%]	7 [26.9%]***
Total	17 [65.4%]	9 [34.6%]	26 [100.0%]

Table 1. Relationship of borderline and pathological arterial Doppler parameters (RI Aum) and venous flow (DV-VU). *-1 acidosis, **-2 acidosis, ***- 7 acidosis (2 died in first 7 days of life)

In fetuses where we verified by antenatal examination the increased resistance index (RI) and pulsatile index (PI) in the umbilical artery (Aum) in any case, we had no abnormal venous flow (in one case were verified acidosis in the fetus). The absence of flow in enddiastolic Aum was verified in 9 (34.6%) infants, while two (22.2%) had pathological flow in DV and VU, in which the blood pH Aum confirmed fetal acidosis (Table 1). AS in both children ranged from 1 to 3. In 7 (77.8%) of women have got neat venous flow, where the borderline acidosis were 5 (55.6%) infants and in 2 (22.2%) was found in normal blood pH Aum. In the AS group 4-7 was identified in 3 (33.3%) and 8-10 in 4 (44.4%) newborns.

In 7 subjects with markedly abnormal Doppler flow through the Aum of the fetuses (reverse end-diastolic flow) in all 7 (100%), we confirmed the pathologic venous flow and the presence of fetal acidosis. Apgar scores of 1-3 had four children (57.1%) and three children (42.9%) were rated with AS 4 to 7. In this group, the two neonates died during the first seven days of life.

Analyzing borderline Doppler flow in the fetal aorta-Ao, who verified in 8 fetuses, we detected one (12.5%) abnormal venous flow, where we confirmed fetal acidosis and Apgar score of 1 to 3. In the remaining seven (87.5%) borderline Ao

RI Ao	DV-VU		Total
	Regular	Pathological	
Borderline	7 [87.5%]*	1 [12.5%]	8 [33.3%]
AEDF	8 [61.5%]*	5 [38.5%]	13 [54.2%]
REDF	0 [0.0%]*	3 [100.0%]	3 [12.5%]
Total	15 [62.5%]	9 [37.5%]	24 [100.0%]

Table 2. Relationship of borderline and pathological arterial Doppler parameters (RI Ao) and venous flow (DV-VU) (Acidosis and low AS). *- Acidosis and low AS

Doppler flow, venous flow rates were normal, blood Aum pH was normal as well as Apgar score (Table 2).

The absence of diastolic flow (AEDF) in Ao was present in 13 patients (54.2%). Measurement of venous flow in 5 (38.5%) of the respondents gave abnormal venous flow and acidosis in all five children, three of whom with AS from 1 to 3 and two from AS 4 to 7,8 (61.5%) children with normal venous flow rates are with normal blood PH Aum and Apgar score. Reverse diastole through Ao was found in 3 fetuses, of which all three (100%) had abnormal venous flow, the birth acidosis and low Apgar score in the first minute, two (66.7%) of the children had AS 1 to 3, and one (33.3%) was evaluated with AS 4 to 7 (Table 2). There was a high statistical significance of fetal venous flow and umbilical artery blood pH, and AS in first minute after birth.

There is justification for measurement and analysis of venous flow in the event of borderline and pathologic findings in fetal arterial system. Reverse diastolic Aum and Ao absolutely correlated with pathologic fetal venous flow rates, where we find the presence of acidemia and low Apgar scores at birth and changes in venous flow indicate fetal asphyxia and precede poor perinatal outcome.

Of the 27 fetuses with borderline Doppler flows through ACM, abnormal venous flow rates were verified in 8 (29.6%) patients and in 11 (40.7%) children were verified acidosis and low AS in first minute of birth. Of 2 abnormal flows (AEDF) in ACM, one was in newborn acidemia with AS 1 to 3, and the other had normal blood pH and rated Aum AS in 1st minute was 4 to 7.

From a total of 96 (80.7%) fetuses with normal C/U ratio, none of them had abnormal venous flow. 10 (10.4%) infants had verified acidemia at birth and in 4 (4.2%) AS 4-7 in the first minute. Of the 23 (19.3%) fetuses with abnormal C/U ratio, in 9 (39.1%) there were abnormal venous flow rates, while the acidosis was found in 10 (43.5%) infants, 6 (26.1%) with AS 1 to 3, and 7 (30.4%) with Apgar score of 4 to 7. In

CU	DV-VU		Total
	Regular	Pathological	
Regular	96 [100.0%]	0 [0.0%]	96 [80.7%]*
Centralization	14 [60.9%]	9 [39.1%]	23 [19.3%]**
Total	110 [92.4%]	9 [7.6%]	119 [100.0%]

Table 3. Relationship of borderline and pathological arterial Doppler parameters [CU] and venous flow [DV-VU] [-10.4% 4.2% acidosis and low AS -10 [43.5%] acidosis and low AS 1-7]. * [10.4% 4.2% acidosis and low AS, **10 [43.5%] acidosis and low AS 1-7]

14 (60.9%) infants, we found normal venous flow (Table 3). Rizzo (13) in a study of 97 fetuses with intrauterine growth retardation (IUGR) examined hemodynamics in DV to values of C/U ratio. With proper C/U ratios there were no changes in venous flow. Changes were significantly increased with pathological C/U ratio and absent flow in end diastole Aum in terms of the appearance of pathological venous flow (Table 3).

Analysis of the results in this study coincides with the above analysis. Most predictive Doppler parameter of arterial flow in predicting pathological venous flow is

Neonatal outcome	pH Aum			Total
	Acidosis	Borderline	Regular	
Regular	17 [14.7%]	29 [25.0%]	70 [60.3%]	116 [97.5%]
Died during the first 7 days	2 [100.0%]	0 [0.0%]	0 [0.0%]	2 [1.7%]
Died after 7 days	1 [100.0%]	0 [0.0%]	0 [0.0%]	1 [0.8%]
Total	20 [16.8%]	29 [24.4%]	70 [58.8%]	119 [100.0%]

Table 4. Relationship between umbilical artery pH and the outcome

	SE	SP	PPV	NPV	P	LP	LN
RI Aum	45.00%	92.93%	56.25%	89.32%	84.87%	43.80%	10.70%
RI Ao	40.00%	91.92%	50.00%	88.35%	83.19%	50.00%	11.70%
RI ACM	5.00%	98.99%	50.00%	83.76%	83.19%	50.00%	16.20%
CU	50.00%	86.87%	43.48%	89.58%	80.67%	56.50%	10.40%
DV	35.00%	97.98%	77.78%	88.18%	87.39%	22.20%	11.80%
VU	35.00%	97.98%	77.78%	88.18%	87.39%	22.20%	11.80%

Table 5. Values of individual Doppler parameters in the assessment of fetal acidosis

reverse flow through the Aum and Ao (100% in our study), followed by lack of end diastole flow in Aum and Ao and ultimately pathological cerebroumbilical ratio (39.1%), (Table 3).

From a total of 119 patients in the intensive care unit (ICU) for more than 24h after birth was visited 29 (27.4%) infants and 20 (16.8%) had acidemia-acidosis (Table 4). Of the 20 neonates, 9 (45.0%) were in perinatal asphyxia. Of 6 infants who had AS in first minute 0-3, 6 (100%) had asphyxia, a total of 11 infants who had at birth the AS of 4-7, 6 of them (54.5%) were in perinatal asphyxia.

Of the total number of women after childbirth, during the first 7

days died two children and 20 days post-partum died one child. Both babies are at birth had acidosis, had low AS at birth, had a pathological CTG, abnormal arterial and venous flow. On the basis of these data, we calculated the perinatal mortality (Mt=1.68%) and morbidity (Mb=24.37%).

ICU/29 newborns / longer than 24 hours:

- 20 infants in acidosis;
- 9 infants in perinatal asphyxia;
- 17 newborns with low AS, 12 of them were in perinatal asphyxia;
- Mb: 24.37%, -Mt: 1.68%

In our research we found that the most sensitive is cerebroumbilical index as Doppler parameter in the assessment of intrauterine fetal condition (Table 5) and that the highest specificity has Doppler flow through the ACM.

5. DISCUSSION

The period from the detection of abnormal flow through the Aum to the emergence of fetal distress or death is different and lasts from several days to several weeks (15-17,19-21).

Our results and results of other studies suggest that changes in venous flows precede poor perinatal outcome of the fetus. Of the various components that are measured in venous flows most significant is wave „A“ which is the best predictor of fetal hypoxia (reflecting the hemodynamic status of the venous reservoir blood returning to the right heart, pressure and contractility of

right atrium and ventricle) (2). Rizzo's Roman study (13) in 1994 examined venous hemodynamics in 79 fetuses with intrauterine growth retardation. They have noticed that the wave "A" has a tendency to increase in fetuses with normal PI Aum. The pregnant women who had had an abnormal PI Aum had significant increase in wave "A", which is directly corresponded to late decelerations and lower pH Aum. The increase of wave "A" is very significant in fetuses with AEDF and RF (in this category are classified as many as 3 of the 4 neonatal deaths).

Tshirikov (18) and colleagues reported that the abnormal CTG findings preceded the abnormal flow through the DV in 52%, while an abnormality was detected in 5.5% of cases. Ferrazzi has noted that about 50% of abnormal CTG finds no change in venous Doppler findings (11, 19).

There is justification for measurement and analysis of venous flow in the event of borderline and pathologic findings in fetal arterial system. Reverse diastolic Aum and Ao absolutely correlated with pathologic fetal venous flow rates, while the presence of acidemia and low Apgar scores at birth. Changes in venous flow precede poor perinatal outcome.

Rizzo (13) in a study of 97 fetuses with intrauterine examined hemodynamics in DV to values of C/U ratio. With proper C/U ratio there were no changes in venous flow. Changes were significantly increased with pathological C/U ratio and absent enddiastolic flow in Aum in terms of the appearance of pathological venous flow. Analysis of the results in this paper coincides with the above analysis. Most predictable arterial Doppler parameters in predicting pathological venous flow is reverse flow through the Aum and Ao (100% in our study), followed by enddiastolic absence in Aum and Ao and ultimately pathological cerebroumbilical ratio (39.1%).

The goal of antepartum fetal monitoring involves testing the state of fetal oxygenation. Ideal antenatal test should have high sensitivity and high specificity. C/U ratio is the

Doppler parameter that best correlated with acid-base status of the fetus and which has the greatest efficacy in the prediction of fetal respiratory vulnerability (22). Efficiency of C/U index is greater than the individual efficiency of PI Aum and PI MCA (22), which is consistent with the results in our study.

6. CONCLUSIONS

- Doppler parameters in the fetoplacental unit are indirect indicators of the respiratory condition of the fetus. There is a connection between the appearance of fetal distress in pathological values of Doppler parameters measured in the arterial and venous system of the fetus.
- Changes in fetal venous flow rates precede poor perinatal outcome. There is justification for measurement and analysis of venous flow in the case of borderline and pathological blood flow.
- Cerebroumbilical index is the most effective Doppler parameter in predicting changes in the venous system of the fetus.
- A high statistical significance between venous fetus blood flow and umbilical artery blood pH, as well as Apgar score in the first minute.
- Analyzing individual Doppler parameters in the assessment of fetal oxygenation by acid-base status, we concluded that the highest sensitivity has cerebroumbilical index and Doppler flows through the umbilical artery, while the highest specificity show Doppler flows through the artery cerebri media, ductus venosus and umbilical vein.

Conflict of interest: none declared

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